

CLAIMS

What is claimed is:

1. An upgradeable optical add/drop module, comprising:
 - an optical input and an optical output;
 - a first bandpass filter with a first pass band and optically coupled to the optical input, comprising a first reflection port and a first transmission port;
 - a second bandpass filter with the first pass band and optically coupled to the optical output, comprising a second reflection port and a second transmission port;
 - a third bandpass filter with a second pass band and optically coupled to the first reflection port, comprising a third transmission port;
 - a fourth bandpass filter with the second pass band and optically coupled to the second reflection port, comprising a fourth transmission port;
 - a first cascaded series of channel filter assemblies optically coupled to the first transmission port;
 - a second cascaded series of channel filter assemblies optically coupled to the second transmission port;
 - a third cascaded series of channel filter assemblies optically coupled to the third transmission port; and
 - a fourth cascaded series of channel filter assemblies optically coupled to the fourth transmission port.
2. The module of claim 1, further comprising an optical switching unit optically

coupled between the first and second cascaded series of channel filter assemblies, and between the third and fourth cascaded series of channel filter assemblies.

3. The module of claim 1, wherein the first bandpass filter, the first cascaded series of channel filter assemblies, the third bandpass filter, and the third cascaded series of channel filter assemblies comprise a de-multiplexer section of the module.

4. The module of claim 3, wherein the first bandpass filter separates a composite optical input signal into a first subset of channels and a second subset of channels, wherein the first subset of channels is transmitted to the first cascaded series of channel filter assemblies via the first transmission port and the second subset of channels is reflected to the third bandpass filter via the first reflection port.

5. The module of claim 4, wherein each assembly in the first cascaded series of channel filter assemblies transmits one channel of the first subset of channels and reflects other channels of the first subset of channels.

6. The module of claim 4, wherein the third bandpass filter separates the second subset of channels into a third subset of channels and a fourth subset of channels, wherein the third subset of channels is transmitted to the third cascaded series of channel filter assemblies via the transmission port and the fourth subset of channels is reflected from the third bandpass filter.

7. The module of claim 6, wherein each assembly in the third cascaded series of channel filter assemblies transmits one channel of the third subset of channels and reflects other channels of the third subset of channels.

8. The module of claim 6, wherein the second bandpass filter, the second cascaded series of channel filter assemblies, the fourth bandpass filter, and the fourth cascaded series of channel filter assemblies comprise a multiplexer section of the module.

9. The module of claim 8, wherein each channel of the first subset of channels is transmitted to an assembly of the second cascaded series of channel filter assemblies, wherein the second cascaded series of channel filter assemblies transmit the first subset of channels to the second bandpass filter via the second transmission port.

10. The module of claim 9, wherein each assembly in the second cascaded series of channel filter assemblies transmit one channel of the first subset of channels and reflects other channels of the first subset of channels.

11. The module of claim 9, wherein each channel of the third subset of channels is transmitted to an assembly of the fourth cascaded series of channel filter assemblies, wherein the fourth cascaded series of channel filter assemblies transmit the third subset of channels to the fourth bandpass filter via the fourth transmission port.

12. The module of claim 11, wherein each assembly in the fourth cascaded series of channel filter assemblies transmit one channel of the third subset of channels and reflects other channels of the third subset of channels.

13. The module of claim 11, wherein the fourth bandpass filter combines the third subset of channels, wherein the third subset of channels is transmitted to the second bandpass filter via the second reflection port.

14. The module of claim 13, wherein the second bandpass filter transmits the first subset of channels and reflects the third subset of channels, wherein the first and third subsets of channels are combined into a composite optical output signal.

15. The module of claim 1, wherein at least one of the channel filter assemblies comprises:

- a first capillary tube comprising a plurality of optical fibers;
- a second capillary tube comprising at least one optical fiber;
- a first quarter pitch GRIN lens optically coupled to the first capillary tube;
- a second quarter pitch GRIN lens optically coupled to the second capillary tube; and
- an optical fiber optically coupled to the first and second GRIN lenses.

16. An upgradeable optical add/drop module, comprising:
an optical input and an optical output;

a de-multiplexer section, comprising:

a first bandpass filter with a first pass band and optically coupled to the optical input, comprising a first reflection port and a first transmission port,

a first cascaded series of channel filter assemblies optically coupled to the first transmission port,

a third bandpass filter with a second pass band and optically coupled to the first reflection port, comprising a third transmission port, and

a third cascaded series of channel filter assemblies optically coupled to the third transmission port,

wherein the first bandpass filter separates a composite optical input signal into a first subset of channels and a second subset of channels, wherein the first subset of channels is transmitted to the first cascaded series of channel filter assemblies via the first transmission port and the second subset of channels is reflected to the third bandpass filter via the first reflection port,

wherein the third bandpass filter separates the second subset of channels into a third subset of channels and a fourth subset of channels, wherein the third subset of channels is transmitted to the third cascaded series of channel filter assemblies via the transmission port and the fourth subset of channels is reflected from the third bandpass filter;

a multiplexer section, comprising:

a second bandpass filter with the first pass band and optically coupled to the optical output, comprising a second reflection port and a second transmission port,

a second cascaded series of channel filter assemblies optically coupled to the

second transmission port,

a fourth bandpass filter with the second pass band and optically coupled to the second reflection port, comprising a fourth transmission port, and

a fourth cascaded series of channel filter assemblies optically coupled to the fourth transmission port,

wherein each channel of the first subset of channels is transmitted to an assembly of the second cascaded series of channel filter assemblies, wherein the second cascaded series of channel filter assemblies transmit the first subset of channels to the second bandpass filter via the second transmission port,

wherein each channel of the third subset of channels is transmitted to an assembly of the fourth cascaded series of channel filter assemblies, wherein the fourth cascaded series of channel filter assemblies transmit the third subset of channels to the fourth bandpass filter via the fourth transmission port,

wherein the fourth bandpass filter combines the third subset of channels, wherein the third subset of channels is transmitted to the second bandpass filter via the second reflection port,

wherein the second bandpass filter transmits the first subset of channels and reflects the third subset of channels, wherein the first and third subsets of channels are combined into a composite optical output signal.

17. A system, comprising:

a composite optical input signal; and

an optical add/drop module, comprising:

- an optical input and an optical output,
- a first bandpass filter with a first pass band and optically coupled to the optical input, comprising a first reflection port and a first transmission port,
- a second bandpass filter with the first pass band and optically coupled to the optical output, comprising a second reflection port and a second transmission port,
- a third bandpass filter with a second pass band and optically coupled to the first reflection port, comprising a third transmission port,
- a fourth bandpass filter with the second pass band and optically coupled to the second reflection port, comprising a fourth transmission port,
- a first cascaded series of channel filter assemblies optically coupled to the first transmission port,
- a second cascaded series of channel filter assemblies optically coupled to the second transmission port,
- a third cascaded series of channel filter assemblies optically coupled to the third transmission port, and
- a fourth cascaded series of channel filter assemblies optically coupled to the fourth transmission port.